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9. ABSTRACT
This paper was presented at the Conference on Strategic Factors in Rural Development in East and Southeast Asia, under the sponsorship of the Council of Asian Manpower Studies, held at Pasay City, Philippines, December, 1976. Its purpose is threefold: 1) to observe the changes in output, area, and yield of the major food grains - rice, wheat, and corn - over the past two decades in Asia; 2) to measure for rice the contribution of increased fertilizer use and irrigation development ot output growth; and 3) to interpret the experience of the past two decades in terms of its significance for sources of output growth in the decade ahead. The analysis is conducted on a national basis for 12 countries in South and Southeast Asia. Taiwan and South Korea are also included in the analysis for comparative purposes. Growth rates are calculated for area, yield, and production during two time periods, 1955-1965 and 1965-1973. This reflects the pre and post high-yielding variety (HYV) situation. Agricultural output can be increased through the expansion of cultivated area or through an increase in the productivity of the existing land area. Prior to 1960, the expansion of the land area was the principal source of output growth in Southeast Asia. The closing of the land frontier after 1960 has necessitated a shift toward the use of modern-yield-increasing inputs. Significant yield gains were achieved through the introduction of modern fertilizer responsive varieties in the last decade. However, more research will be needed to provide answers to critical questions about the further expansion of modern technology and development of water control. The efficiency with which irrigation and modern inputs are developed and used must be improved or output growth will be slowed down and the cost of food grains will rise.

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SOURCE OF OUTPUT GROWTH IN ASIAN FOOD GRAINS*

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Agricultural output can be increased through the expansion of cultivated area or through an increase in the productivity of the existing land area. In South and Southeast Asia prior to 1960, the expansion of land area provided the principal source of output growth New lands were opened up at a pace roughly in keeping with the growth in the agricultural labor force.

The gradual closing of the land frontier after 1960 -- more pronounced in rice than in upland crops -- has necessitated a shift toward the use of modern-yield-increasing inputs. The speed with which this transformation occurs determines the degree to which output can keep pace with population growth and generate the food surpluses needed for agricultural development.

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The means for achieving a rapid transformation appeared to be at hand in the 1960s with the development of the so-called high yielding varieties of rice and wheat. But it is now generally recognized that while food production has kept pace with population growth in the region as a whole, we seem to be no nearer to solving the food problem today than we were a decade ago. In fact, the question has been raised that the "green revolution" may be running out of steam.

The purpose of this paper is threefold: (a) to observe the changes in output, area, and yield of the major food grains -- rice, wheat, and corn -- over the past two decades; (b) to measure for rice the contribution of increased fertilizer use and irrigation development to output growth; (c) to interpret the experience of the past two decades in terms of its significance for sources of output growth in the decade ahead.

The analysis is conducted in a national basis for 12 countries in South and Southeast Asia. Taiwan and South Korea, two East Asian countries in a more advanced stage of development, are also included in the analysis for comparative purposes. Growth rates for area, yield, and production are calculated for two time periods, 1955-1965 and 1965-1973, reflecting the pre and post HYV situation.

OUTPUT GROWTH IN CEREAL GRAINS

In this section, we examine the changes in output growth and the technical factors that have influenced this growth for the major cereal grains -- rice, wheat, and corn. Rice is the most widely grown of the cereal grains being the main food staple in most of Asia. Wheat is grown principally in Northern India, Pakistan, and Afghanistan. Corn is grown widely in a number of countries in South and Southeast Asia.

The initial high yielding semi-dwarf varieties of wheat and rice came principally from Mexico and the Philippines, respectively, but to a large degree, have been replaced by locally-developed crosses between exogenous lines and local materials. There has been no comparable breakthrough in corn yields although the growth in corn production continues to be very pronounced in some parts of Southeast Asia. Table 1 shows percent of the area currently devoted to the high yielding varieties of rice and wheat. It is clear from this table that there is considerable variation in the rate of adoption among countries. There has also been considerable variation in adoptions within countries, the variation appearing to be related more to physical environment than to institutional factors.

RICE

In the mid-1960s prior to the introduction of the new varieties, the general level of rice yields in South and Southeast Asia was very low compared to Taiwan, South Korea, and other countries with a longer history of exploiting the potential for increasing farm productivity and output by the application of science-based technologies (Table 2).

In the mid-1950s, the rice yields of 2.6 t/ha in Korea and 2.8 tons in Taiwan were twice the level obtained in South and Southeast Asian countries apart from Indonesia and Malaysia where yields averaged about 2 t/ha; and by the mid 1960s, the differential was even greater because of the more rapid technical progress in Korea and Taiwan. In the period since 1965, however, Pakistan, Indonesia, Sri Lanka, and

the Philippines registered annual increases in yield in excess of 2% and narrowed the gap. It will be noted that the rates of increase in rice yields in Korea and especially in Taiwan were substantially lower during the 1965-1973 period than in the previous decade suggesting that relatively little "slack" for potential yield increases remained. However, beginning in 1971 in Korea, the introduction of a new generation of high yielding varieties obtained by crossing Indica and Japonica varieties significantly raised the yield ceiling and the rate of growth of rice yields has again accelerated.

By the early 1960s, it was becoming apparent in many Asian countries that there was very little land remaining that could be developed into rice paddies at reasonable cost. In order to maintain the existing production trend (let alone increase production), it was essential to introduce a yield increasing technology. It will be noted subsequently that the land area constraint does not appear to have been operating in the same manner in the case of either wheat or corn. Between 1955-65 and 1965-73, there was a substantial decline in the contribution of land area to rice output growth from 1.3% per annum to 0.9% for South and Southeast Asia as a whole. Unfortunately, official government statistics normally report gross rather than net area. The decline in the net area has been offset to some degree by the expansion of the area double cropped. We will discuss this in more detail in the next section.

To what degree was an increase in yield able to compensate for the area decline? In Table 2, the countries have been ranked from top to bottom according to the growth in rice yield in the period 1965-73. In

Pakistan, which heads the list, rice is grown under conditions of controlled irrigation and dry climate ideally suited to the new varieties. The increase in yields exceeded 6% per annum and total rice output grew at 7.5% per annum. This was associated with a remarkably rapid increase in the percentage of rice planted to high yielding varieties from less than 1% in 1967-68 to 42% in 1973-74. In fact, the success of the new varieties in Pakistan led to a decline in the acreage of the high quality local basmati rice which commands a premium in the export markets. To protect the supply the government raised the support price of basmati to twice the level of the high yielding varieties.

Burma, Bangladesh, and Thailand all have experienced a very low growth in yields. All three countries are located in major river deltas. The development of rice production in these deltas during the latter part of the 19th century resulted in substantial surpluses and brought Burma and Thailand to prominence as rice exporters. It is paradoxical that the environment which favored surplus rice production in this earlier period has been unsuited for the new varieties. The major deterent to the adoption of these varieties in these three countries and elsewhere has been the lack of water control. Either too little or too much water can seriously affect the development of these varieties. Due to their shorter stature and shorter growth duration, these modern varieties are frequently more sensitive than the local varieties to flooding and drought. The risk of applying fertilizer and other inputs is naturally increased under uncontrolled water conditions.

The experience of India on a country wide basis has been similar to the regional average, but the national average obscures the marked contrast between different parts of India. North India compares favorably with Pakistan in both adoption of new varieties and yield gains while in much of the waterlogged areas of Eastern India, growth in yield has been low during the wet season and local varieties still predominate. Many farmers in these regions adopt new varieties and modern inputs during the dry season, but switch back to the traditional varieties during the wet, again emphasizing the impact of the physical environment.

Sri Lanka, Indonesia, and the Philippines, all experienced a growth in yield per hectare in 1965-73 in excess of 2%. These countries also have placed major emphasis in recent years on the development of irrigation and expansion in the area double cropped. In six countries, the growth in rice cropped areas has exceeded 1% per annum. In Sri Lanka and Malaysia, the growth in cropped areas has exceeded 3% and 4% per annum, respectively. Growth in total rice production has exceeded growth in population in the above four countries plus India and Pakistan. In the remaining countries of the region including Nepal, Bangladesh, Burma, Thailand, Laos, and Cambodia, growth in rice output has not kept pace with population growth.

Based on yield data from experiment stations in a number of locations in Asia, the yield potential of the high yielding varieties is about 6.0 t/ha in the dry season and 4.8 t/ha in the wet season (Herdt 1976). In India, the yield of the new varieties (average of two seasons) was initially a little over 2 t/ha compared to about 1 t/ha for traditional varieties (Dalrymple 1975). Part of this gap between the experiment station and farm yield may be explained by differences in the method of

estimating yields, but even allowing for this, the gap may be as much as 3 t/ha. We believe that a major portion (perhaps 2/3 to 3/4) of this gap can be explained by the differences between the environment of the experiment station and the farmers field. Furthermore, as the new varieties have spread over time to less favorable environments, the yields on farmers fields has been further reduced in India enlarging the size of the gap.

To the degree that this gap can be explained by environmental differences, we can refer to it in the short-run as a technical gap. It is clear that there is still a large portion of the Asian rice-growing environment for which the existing new varieties are not suited. In the long-run, decisions can be made to either improve the environment or tailor varieties to the poor environment, and in this context the issue takes on a socio-economic dimension.

WHEAT

The introduction of high yielding, semi-dwarf varieties from Mexico, which began in 1965, has had a quite different impact than the new rice varieties. Wheat is the dominant cereal only in Pakistan, Afghanistan, and in Northern India. Consequently, the areas affected by the new varieties of wheat has been considerably more limited. Although the yield gain in Afghanistan during the 1965-73 period was relatively moderate, it represented a significant reversal of a declining trend (Table 3). Moreover, it meant over a ten-fold increase in the rate of growth of wheat output from a mere 0.2% between 1955 and 1965 to 2.4%

despite the fact that the growth in area planted to wheat declined from 1.1% to 0.3% between the two periods.

The rates of increase in wheat yields in Pakistan and India were particularly impressive. In India, the increase was associated with a rapid increase in yield and expansion of the area planted to new varieties. The rate of increase in yield in Pakistan was slightly higher than in India, but the rate of growth in wheat area was not nearly as rapid. Nevertheless, the 7.5% annual growth rate in total output meant a very large increase in production. From an average level of 4.2 M tons during the years 1963-67 output rose to nearly 7.3 M tons in the 1970-74 period.

In India, wheat production more than doubled between 1963-67 and 1970-74, rising from 10.9 to 22.4 M tons. In the earlier period, wheat output was only 24% as large as rice production, but in the later period the wheat crop on average was nearly 40% as large as the output of paddy. In fact, the 12.5 M ton increase in wheat production accounted for a little over half of the total growth in cereals output between 1963-67 and 1970-74. It was, thus, the major factor responsible for a reduction in cereal imports from an average level of 8.2 M tons during 1963-67 to an average of 3.5 M tons in the later period. The levels of wheat production attained in India and Pakistan during 1970-74 period are especially impressive given the reduced availability and high cost of fertilizer during 1973 and 1974. It is also worth mentioning that wheat production more than doubled in Bangladesh between 1963-67 and 1970-74, although it remained a minor crop compared to rice.

Thus, we can see that unlike rice, which encountered a land constraint, output growth in wheat has benefited from an expansion in the growth of area and yield. As the new varieties took hold in the Punjab and other parts of Northern India, they spread rapidly to the southeast down the Gangetic Plain into the Eastern Uttar Pradesh, and the northern portions of Bihar, West Bengal, and Bangladesh -- wherever water was available. In some cases, the wheat replaced inferior grains such as corn, sorghum, or millets or to a lesser extent, pulses. In other cases, it was possible to grow two crops, wheat followed by rice, where only one had grown before.

Wheat yields on the experiment stations were about 4-1/2 t/ha and were initially about 2-1/2 t/ha in farmers field in India. Thus, the yield gap was almost as large as in the case of rice. Environment is also a critical factor explaining this gap. As the new wheat varieties spread and the area expanded rapidly, the yield gap widened and average farm yields of high yielding varieties fell to only 1.5 t/ha (Dalrymple 1975). We can only conclude that among the more recent adopters, the environment is not as well suited to the new varieties.

CORN

Among the countries of South and Southeast Asia, corn is of considerable importance in Afghanistan, Nepal, Pakistan, India, Indonesia, the Philippines, and Thailand. In all countries except Thailand, the bulk of the corn crop is consumed domestically as a food grain.

Only Pakistan, the Philippines, and Thailand registered significant increases in output between 1963-67 and 1970-74. As noted previously, there has been no major technological breakthrough in corn. Much of the increase in output has been due to area expansion, although there has been steady progress in yields, particularly in the Philippines. Downy mildew, a fungus disease, continues to be a major constraint to increase in corn yields.

The most spectacular growth in corn production has been in Thailand. The development of the export market and opening up of new areas to corn production was stimulated by the construction of new and improved highways. Essentially, all of the Thai crop is exported as a livestock feed principally to Japan and Taiwan.

SOURCE OF OUTPUT GROWTH IN RICE

The contributions of irrigation and fertilizer to output growth in rice are examined in more detail in this section. The first step is to breakdown the contribution of area and yield in more detail (Fig. 1). Aggregate crop area changes can be due to a change in the total land area and the area double-cropped. Aggregate yield increases can be partitioned between increases due to a higher proportion of the area irrigated and a higher use of yield-increasing inputs, such as new seed and fertilizer. In the computation procedure we use initially, this latter contribution is calculated as a residual.

Following the above format, we examined the sources of output growth in the Philippines (Table 5). In the earlier period, the major contribu-

tion of increased production was irrigation (double cropping and quality) which accounted for 1.82% of a total 2.41% annual growth. Land area expansion and seed-fertilizer were not important. In the latter period, the contribution of land area became negative due principally to the decline in upland rice. The contribution of irrigation expanded with the area double-cropped more than offsetting the decline in net area. New varieties and modern chemical inputs accounted for an output increase of 2.00% per annum.

Mellor (1976) has undertaken a similar analysis of food grains in India, although his input classification is somewhat different (Table 6). Nevertheless, there is a similarity both in magnitude and sources of output growth for rice in the Philippines and for food gains in India. The shift toward fertilizer and irrigation as the major source of output growth in the 1965-73 period has been significant in both countries.

There is difficulty in extending the analytical procedures followed in the Philippines to other countries because of the lack of data on the rice area double-crop irrigated. In Mellor's analysis he assumes, in calculating the contribution of fertilizer, that 1 kg of fertilizer nutrients (N, P, or K) will produce 10 tons of grain. Using this same rule of thumb, we computed the contribution of fertilizer for the Philippine situation. The values, shown in the last row of Table 5, compare favorably with the method of calculating fertilizer contribution as a "residual."

Table 7 shows the change in the area irrigated and the contribution of fertilizer to output growth from eight Asian countries from the mid-1960s to the early 1970s. The contribution of fertilizer is estimated using the same rule of thumb, i.e., 1 kg N, P, or K yields 10 kg of rice.

In India, Indonesia, the Philippines, and Sri Lanka, yield grew at 2.4 to 2.9% and fertilizer at 10.4 to 19.8% accounting for a major portion of the yield increase. However, the residual, in this case identified principally with a rise in proportion of irrigated area, also contributed importantly to the yield growth in all four countries. In India, growth in irrigated rice area was 1.6% per annum, but in the other three countries, the growth has been from 2.7 to 3.0%.

Burma and Thailand present a very different picture. In Burma, there has been very little growth in production, while in Thailand, growth in production is due almost entirely to continued expansion of unirrigated area. In fact, the proportion of irrigated to unirrigated area declined which must have had a depressing effect on yields.

Still another situation is reflected in South Korea. Irrigation development and fertilizer continue to be important sources of output growth. But, because the level of fertilizer input is already very high, the level of fertilizer efficiency appears to be less than in the other countries. Assuming that 1 kg N, P, or K produces 10 kg grain results in a fertilizer contribution in excess of the total yield gain and, hence, a negative residual. It seems most likely that the efficiency is much lower than this.

In Taiwan, production growth has been only 0.4% per annum. Both the area in rice and the amount of fertilizer per hectare seem to have declined slightly.

FUTURE SOURCES OF GROWTH IN FOOD PRODUCTION

Summarizing our analysis of the previous two sections, Asian countries can be divided into three broad categories in terms of their performance in rice output growth over the past decade: (a) those who have been able to maintain a fairly rapid growth of 2% or more by combining an expansion in irrigation with modern inputs -- India, Indonesia, Malaysia, Pakistan, Philippines, and Sri Lanka; (b) those whose growth rate has been slowed down in major part by the inability to boost yields through extensive adoption of the modern seed-fertilizer technology -- Bangladesh, Burma, and Thailand; and (c) those whose growth rate has slowed down because they appear to be approaching a ceiling in terms of the yield potential of the technology -- South Korea and Taiwan.

We assume that these latter countries are sufficiently far advanced in terms of economic development that acquisition of adequate food supplies will provide no serious problem. But the question of how the growth in rice production will be maintained in the developing economies of South and Southeast Asia remains a critical issue.

A decade ago, most countries in the region were just beginning to expand their use of fertilizer and other modern inputs. The advent of the modern varieties has greatly speeded up this process. But it now appears that much of the slack has been taken up with the adoption of

new varieties and modern inputs in the suitable environments. In the absence of new land areas suitable for rice production, there are now three alternatives for expanding output growth in the decade ahead: (a) to close the gap between farm yield potential and actual farmer's yields through the improvement of extension systems, credit, and input distribution, etc.; (b) to expand and improve the irrigation system so that an increasing proportion of the cultivators can take advantage of the existing modern seed-fertilizer technology; and (c) to develop varieties of rice that are fertilizer responsive but better adopted to the less favorable soil and water environments of Asia.

Herdt (1976), in his paper, has discussed the potential for raising yields through the first method of getting farmers to make fuller use of existing technology. Fig. 2 (Moorman, unpublished) shows conceptually the alternatives for raising yield potential. In the case of rice, by improving the environment through irrigation, land type 2a can be shifted to land type 1. Alternatively, this can be accomplished by changing the plant type to suit the environment.

Over the past few years, the International Rice Research Institute has been working on this latter alternative. As yet, however, new varieties and technology that substantially raise the potential of the areas of poorer water control have not been developed. There appears to be no prospect for a major breakthrough in the near future.

The above discussion suggests that maintaining output growth in the decade ahead is going to be more difficult and more costly than in the past decade. The potential rate of growth in rice production now

depends principally on the rate of development of water control irrigation and drainage. There appears to be a growing recognition of the importance of irrigation in many of the developing countries. But given the high cost of irrigation development, there is surprisingly little interest on the part of either national governments or international lending agencies in developing ways to minimize the cost of development and to improve the efficiency in operation of the system.

In summary, output growth of Asian rice and food grain production is becoming increasingly dependent upon the use of modern inputs and development of irrigation. In the last decade, significant yield gains were achieved through the introduction of modern fertilizer responsive varieties. But much of the slack seems to have been taken up. As we look to the decade ahead, more research will be needed to provide answers to critical questions regarding the further expansion of modern technology and development of water control. If we cannot improve the efficiency with which irrigation and modern inputs are developed and used, we will almost certainly witness a slowing down of output growth and a rise in the cost of food grains.

Table 1. Estimated area planted to high-yielding varieties (HYVs) of rice and wheat in Asian developing countries, 1973-74.

	Rice		Wheat	
	Area Planted to HYVs (000 ha)	% of Total Rice Area	Area Planted to HYVs (000 ha)	% of Total Wheat Area
Sri Lanka	368.4	64.5		
Philippines	2176.6	63.4		
Pakistan	636.6	42.1	3472.3	59.0
Malaysia (West)	217.0	36.7		
Indonesia	3100.8	36.6		
South Vietnam	890.0	31.1		
India	9718.2	25.6	10911.0	57.4
Nepal	205.1	17.1	206.8	75.5
Bangladesh	1584.8	15.6	29.1	23.1
Korea, Rep. of	139.0	11.7		
Burma, Union of	252.6	5.1		
Thailand[1/]	400.0	5.0		
Afghanistan			475.0	16.1

1/ Unofficial estimate.

Source: Dalrymple, Dana G., "Development and Spread of High-Yielding Varieties of Wheat and Rice in the Less Developed Nations," Economic Research Service, U. S. Department of Agriculture in Cooperation with U. S. Agency for International Development, August 1976, p.110, 112, 114-5.

Table 2. Summary of paddy yields and annual compound growth rates of paddy area and yields in selected Asian countries.

Country	Paddy Yields 1/ (ton/ha)			Annual Growth Rate (%)			
				1955-65		1965-73	
	1955	1965	1973	Area	Yield	Area	Yield
Pakistan	1.3	1.5	2.4	3.25	1.21	1.11	6.44
Indonesia	2.0	2.1	2.7	0.90	0.51	1.84	2.76
Sri Lanka	1.6	1.9	2.3 2/	2.88	2.10	3.16 3/	2.37 3/
Philippines	1.2	1.3	1.6	1.24	1.10	0.86	2.52
India	1.3	1.5	1.7	1.26	1.30	0.61	1.86
Korea, Rep. of	2.6	4.3	4.9	1.08	4.90	-0.12	1.82
Malaysia (West)	2.1	2.5	2.9	3.41	1.97	4.67	1.72
Burma, Union of	1.5	1.6	1.7	1.93	0.94	0.13	0.71
China, Rep. of	2.8	3.9	4.0	-0.03	3.53	-0.30	0.45
Bangladesh	1.4	1.7	1.7	1.10	1.98	0.60	0.45
Thailand	1.6	1.9	1.9	1.73	1.73	1.84	0.23
Nepal	0.9	1.9	1.7	-1.71	8.24	3.02	-1.42
South & Southeast Asia*	1.4	1.6	1.9	1.28	1.41	0.91	1.71

*Countries included in South and Southeast Asia are Bangladesh, India, Nepal, Pakistan, Sri Lanka, Burma, Indonesia, West Malaysia, Philippines and Thailand.

1/ Five year moving averages centered on the years shown.

2/ Average for 1970-74.

3/ Annual compound growth rate for 1965-72.

Table 3. Summary of wheat yields and annual compound growth rate of wheat area and yields in selected Asian countries.

Country	Wheat Yields 1/ (ton/ha)			Annual Growth Rate (%)			
				1965-66		1965-73	
	1955	1965	1973	Area	Yields	Area	Yields
Pakistan	0.7	0.8	1.2	1.87	1.56	1.41	4.76
India	0.7	0.9	1.3	1.36	2.67	4.68	4.91
Afghanistan	1.0	0.9	1.1	1.07	-0.88	0.33	2.08
South & Southeast Asia*	0.8	0.8	1.3	1.49	0.62	3.51	5.34

*Countries included in South and Southeast Asia are Afghanistan, Bangladesh, India, Pakistan and Burma.

1/ Five year moving averages centered on the years shown.

Table 4. Summary of maize yields and annual compound growth rate of maize areas and yields in selected Asian countries.

Country	Maize Yields[1/] (ton/ha)			Annual Growth Rate (%)			
				1955-65		1965-73	
	1955	1965	1973	Area	Yield	Area	Yield
Philippines	0.6	0.7	0.8	3.46	1.64	3.48	2.27
Thailand	1.3	1.9	2.2	23.59	4.24	8.36	1.50
Indonesia	0.9	1.0	1.1	3.32	0.15	-0.69	1.15
India	0.8	1.0	1.0	2.56	2.78	2.18	0.65
South & Southeast Asia*	0.9	1.0	1.1	3.18	1.66	1.94	0.67

*Countries included in South and Southeast Asia are Afghanistan, Bangladesh, India, Nepal, Pakistan, Sri Lanka, Burma, Indonesia, West Malaysia, Philippines, and Thailand.

1/ Five year moving averages centered on the years shown.

Table 5. PHILIPPINES: Annual average growth rates in production, area and yield of rice, 1955-1973.

	1955-65	1965-73	1955-73
		(in percent)	
Production	2.41	3.43	2.86
Area	1.24	0.86	1.07
Physical area	0.30	-0.83	-0.17
Double cropping	0.94	1.69	1.24
Yield	1.10	2.52	1.73
Quality of land a/	0.88	0.52	0.84
Residual b/	0.22	2.00	0.89
	(0.29)	(1.72)	(0.91)

a/ This measure reflects the proportion of land in irrigated, rainfed or upland palay.

b/ This measure reflects the use of the modern seed-fertilizer technology.

Figures in parenthesis are the changes in yield due to changes in use of fertilizer assuming 1 kg N, P, or K produces 10 kg paddy.

See Appendix for calculating procedures.

Table 6. INDIA: Annual average growth rates in foodgrain production attributed to specified input.[a/]

	1955-65	1965-73	1955-73
		(in percent)	
Production	2.21	3.33	2.71
Unirrigated land	0.06	0.11	0.09
Irrigated land	0.36	0.89	0.61
Intensification of labor[b/]	1.25	0.45	0.82
Fertilizer	0.54	1.88	1.19

a/ Adopted from John W. Mellor, The New Economics of Growth, Cornell Univ. Press, 1976, Appendix Table 9, See Appendix Table.

b/ This value is comparable to "quality of land" in Table 5, since in both cases, the measurement is the effect of increasing yield as a consequence of a higher proportion of land area under irrigation.

Table 7. Estimated shares in paddy output attributed to area and yield.[a/]

	Production (000 m.t.)	Attributed to Area: Irrigated (thousand hectares)	Unirrigated	Upland	Total	Attributed to Yield: Fertilizer (kg.of NPK/ha)	Residual	Yield (ton/ha)
INDIA								
Average 1963-67	52,503	13,412	22,434	-	35,846	7.777		1.465
Average 1968-72	61,319	14,460	22,762	-	37,252	19,198		1.646
Annual Compound Growth Rate 1965-70	3.2	1.6	0.3		0.8	19.8		2.4
		(19.2)	(5.8)	-	(25.0)	(47.3)	(27.7)	(75.0)
INDONESIA								
Average 1963-67	15,478	5,739[b/]	-	1,510	7,249	9.000	-	2.134
Average 1970-74	21,571	6,923[b/]	-	1,337	8,260	28,907	-	2.610
Annual Compound Growth Rate 1965-72	4.8	2.7	-	-1.7	1.9	18.1	-	2.9
		(46.4)		(-6.8)	(39.6)	(25.2)	(35.2)	(60.4)
PHILIPPINES[e/]								
Average 1963-67	4,113	1,102	1,508	549	3,159	7.61		1.302
Average 1971-75	5,386	1,394	1,578	411	3,383	24.90		1.592
Annual Compound Growth Rate 1965-73	3.4	3.0	0.6	-3.6	0.9	16.0		2.5
		(33.1)	(7.9)	(-15.6)	(25.4)	(44.5)	(30.1)	(74.6)
SRI LANKA								
Average 1958-62	889	314	233	-	547[c/]	18.1		1.625[d/]
Average 1966-70	1,298	392	258	-	650[c/]	40.0		1.997[d/]
Annual Compound Growth Rate 1960-68	4.8	2.8	1.3		2.2	10.4		2.6[d/]
		(34.7)	(11.1)		(45.8)	(31.8)	(22.3)	(54.2)
BURMA, UNION OF								
Average 1963-67	7.751	667	4,118	-	4,785	1.356		1.620
Average 1971-75	8,284	811	4,024	-	4,835	6.490	-	1.713
Annual Compound Growth Rate 1965-73	0.8	2.5	-0.3	-	0.1	21.6		0.7
		(35.8)	(-23.3)	-	(12.5)	(47.8)	(39.7)	(87.5)
THAILAND								
Average 1963-67	11,456	1,706	4,447	-	6,153	3.802		1.862
Average 1970-74	13,237	1,808	5,227	-	7,035	7.301		1.880
Annual Compound Growth Rate 1965-72	2.1	0.8	2.3	-	1.9	9.8		0.1
		(10.8)	(82.2)	-	(93.0)	(13.6)	(-6.6)	(7.0)
KOREA, REPUBLIC OF								
Average 1963-67	5,149	992	194	23	1,209	122.19		4.262
Average 1970-74	5,713	1,101	78	15	1,194	205.85		4.784
Annual Compound Growth Rate 1965-72	1.5	1.5	-12.2	-5.9	-0.2	6.7		1.7
		(96.6)	(-102.8)	(-7.1)	(-13.3)	(181.8)	(-68.5)	(113.3)
TAIWAN								
Average 1963-67	3,012	362	410	-	772	213.8		3.897
Average 1969-73	3,091	403	359	-	762	165.8		4.056
Annual Compound Growth Rate 1965-71	0.4	1.8	-2.2	-	-0.2	-4.1		0.6
		(205)	(255)	-	(-50.0)	(-452.8)	(602.8)	(150.0)

a/ Figures in parentheses indicate the percent of increased in production over the period which is attributable to each input.
b/ This includes rainfed area.
c/ Refers to gross harvested area.
d/ Yield per hectare was calculated on the basis of gross harvested area.
e/ Data on area and yield are from national source and are different from FAO figures.

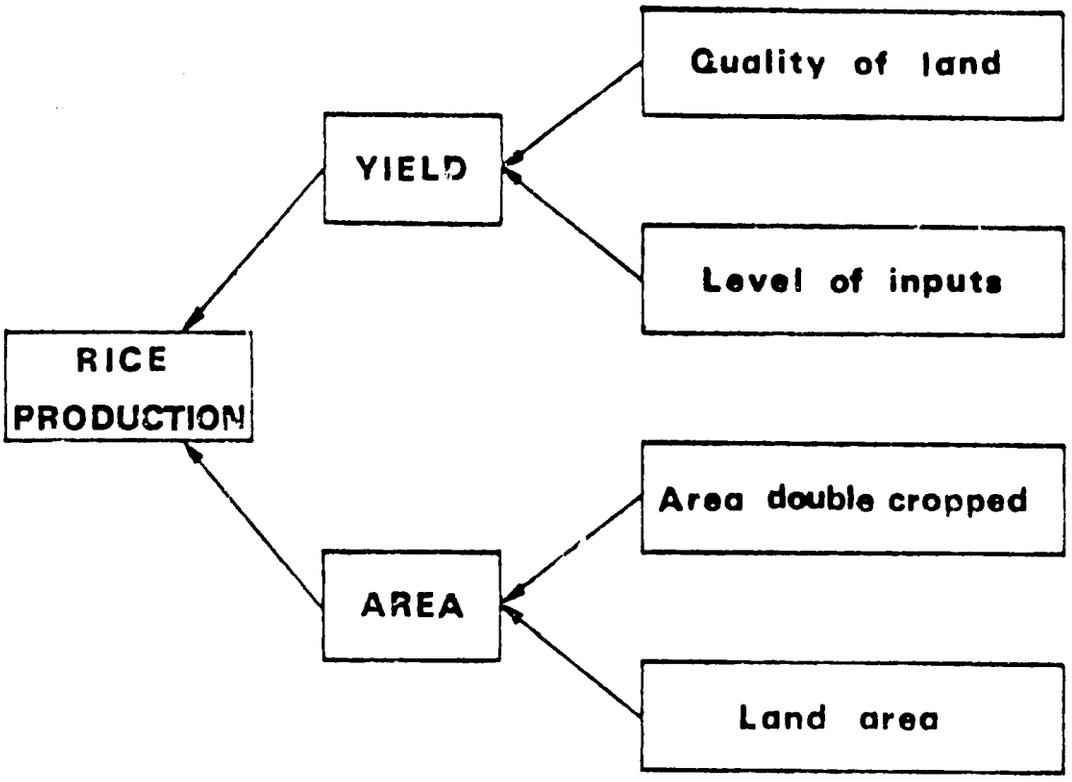

Fig. 1. Contribution of yield and area to rice production.

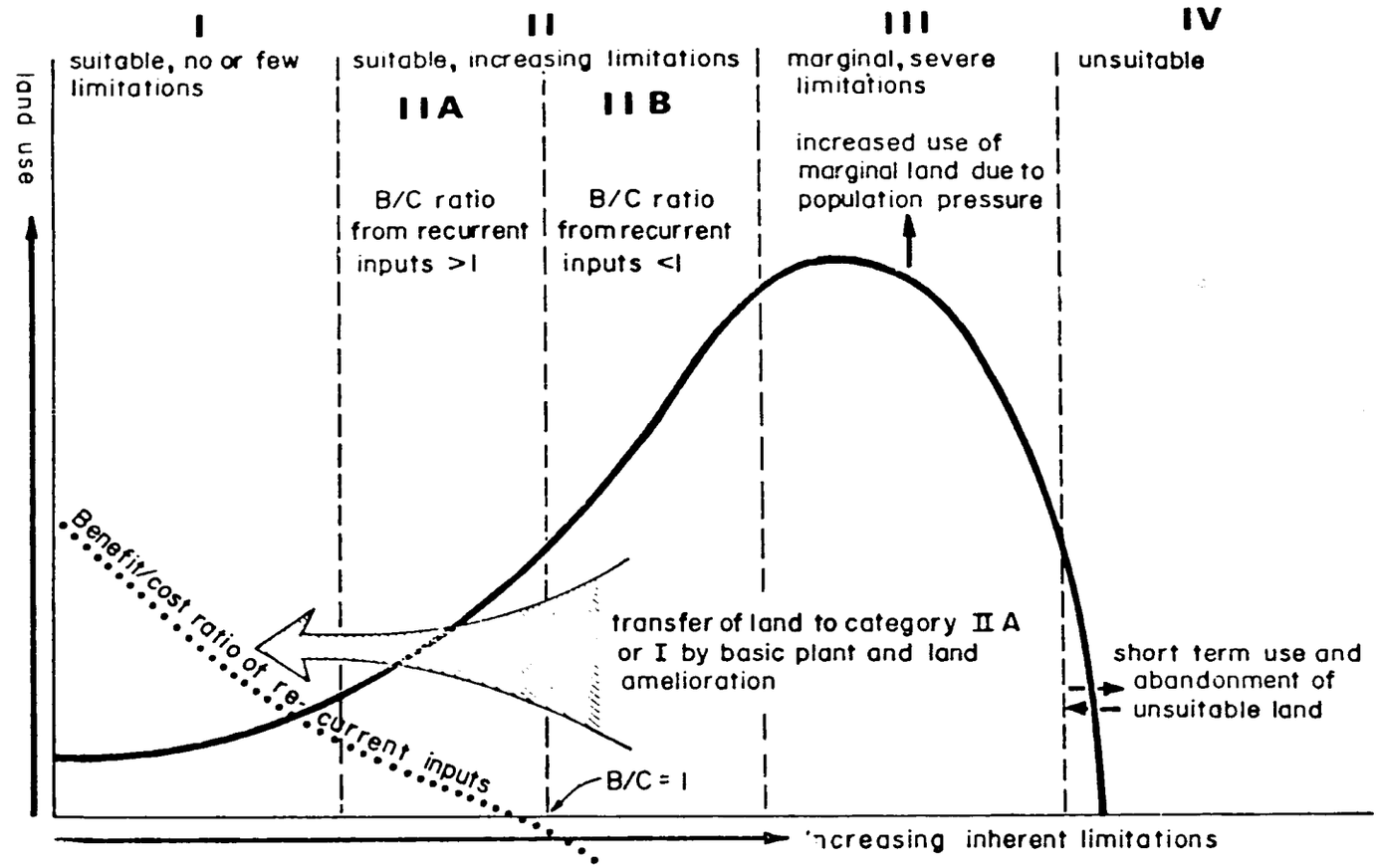

Fig.2. Moorman's model of the relation of land in use for specific agricultural purpose and land quality.

APPENDIX

The following formulas were used in calculating the area and yield contribution to output growth, (Table 7) and the further breakdown of land area and yield (Table 5).

1. Breakdown of source of change in rice output by area and yield.

   a) due to change in area (%) compute $\frac{\log a}{\log p} \times 100$

   where: log a is (log of area 1971-75) - (log of area 1963-67).

   log p is (log of production 1971-75) - (log of production 1963-67).

   b) due to change in yield (%) compute as in 1a above but log of yield figures is used in place of Log of area.

2. Breakdown in the source of change in rice crop area into change in land area and change in double cropped area.

   a) due to change in land area (%)

   compute $\frac{l\ a}{a} \times 100$

   where: l a is (land area 1971-75) - (land area 1963-67)
   a is (crop area 1971-75)- (crop area 1963-67)

   b) due to change in double cropped area (%) compute as in 2a above but double cropped area is used in place of land area.

3. Breakdown in the source of change in yield into <u>better quality of land</u> and <u>residual</u> as a proxy for contribution of modern inputs.

a) due to better <u>quality of land</u> (%)

compute: $\frac{q}{y} \times 100$

where: $q = (\text{yield } 1971\text{-}75) - \frac{(q^* \ 1963\text{-}67)}{a \ 1963\text{-}67}$

$y = (\text{yield } 1971\text{-}75) - (\text{yield } 1963\text{-}65)$

$q^* \ 1963\text{-}67 =$ (yield of upland rice 1971-75 x area upland rice 1963-67)

+ (yield rainfed rice 1971-75 x area rainfed rice 1963-67)

+ (yield irrigated 1st crop 1971-75 x area irrigated 1st crop 1963-67)

+ (yield irrigated 2nd crop 1971-75 x area irrigated 2nd crop 1963-67)

$a \ 1963\text{-}67 =$ upland area 1963-67 + rainfed area 1963-67 + irrigated 1st crop area 1963-67 + irrigated 2nd crop area 1963-67

b) due to <u>residual</u> (modern inputs) (%)

compute $100 - (\frac{q}{y} \times 100)$